PHENIX p+p and Spin Results

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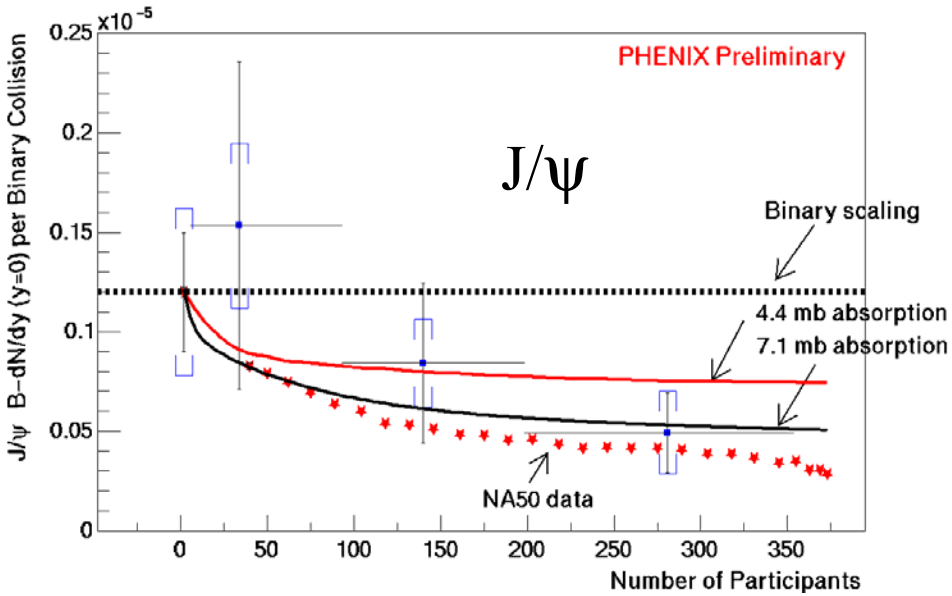
for ***PHENIX collaboration***

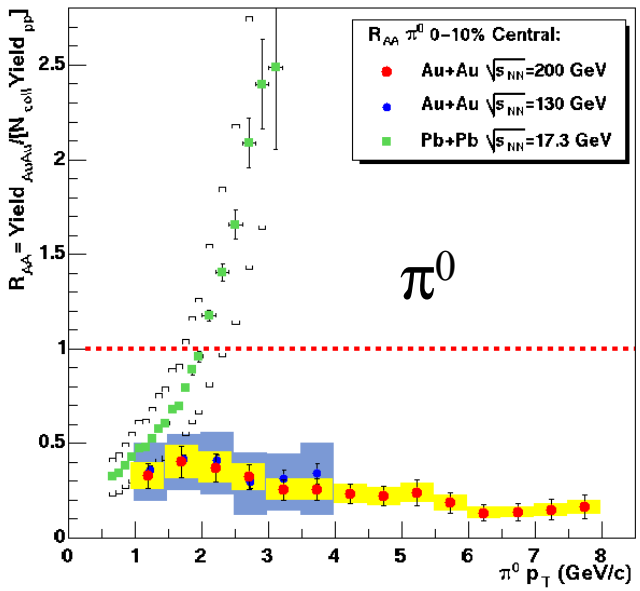
Outline

- Physics Motivation in p+p collisions
- Results and analysis status from run2002
- Plan for near future

p+p Physics Motivation at PHENIX

(I)*Baseline for interpreting Au+Au result*





p+p Physics Motivation at PHENIX

(II)Proton Spin Structure

Longitudinal-spin asymmetry:

* gluon polarization measurement:
  - *direct photon*
  - *hadron production*
  - *open heavy flavor with e, u, eu*
  - *-J/ψ*

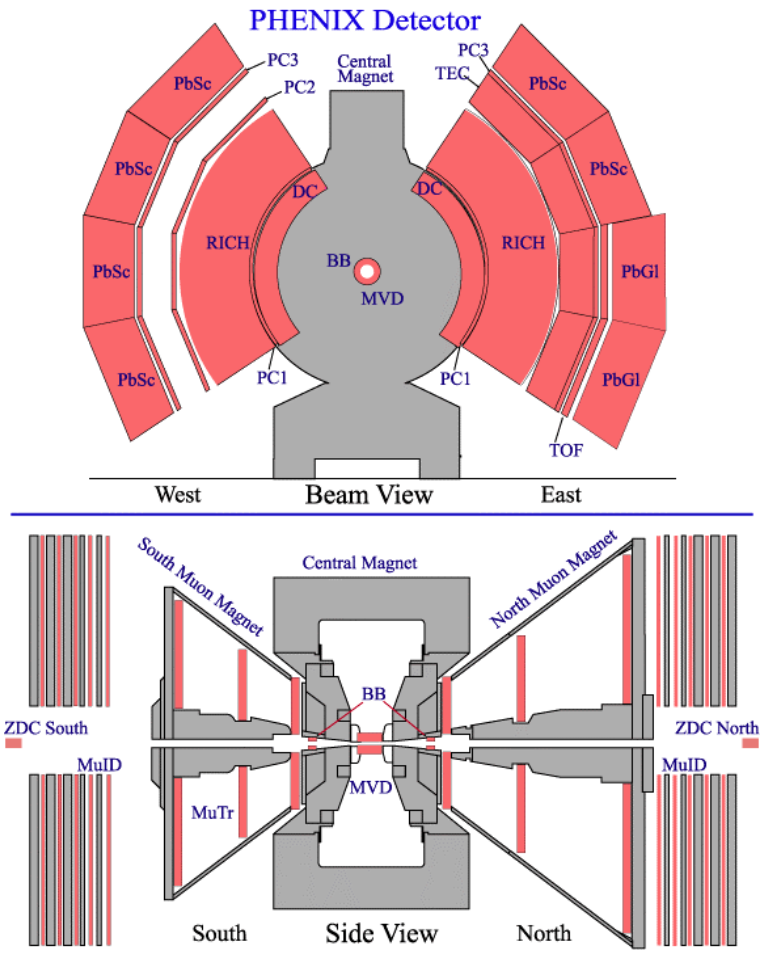
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_z$$

* anti–quark polarization measurement:
  - *parity violating* $W^{+/-}$ – flavor decomposition of quark sea

Transverse-spin asymmetry

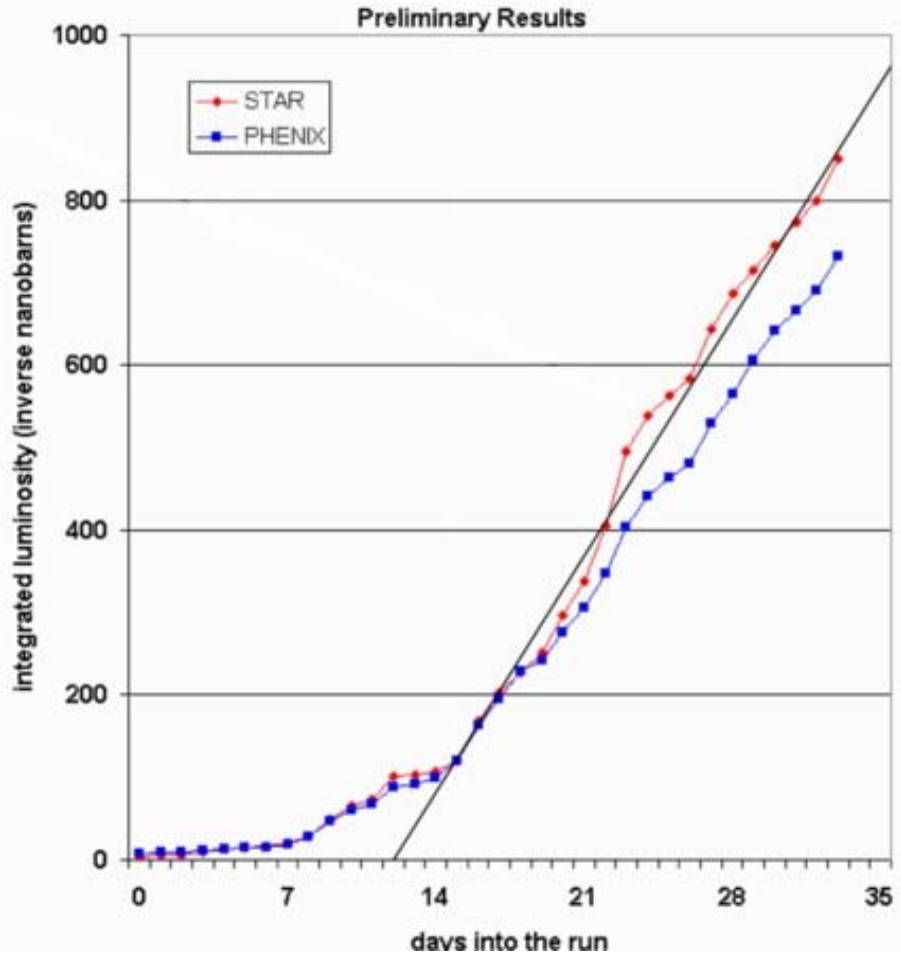
- A_N: π^0 , *charged hadron*
- *Transversity*

PHENIX Central Arm and Muon Arm Detector



- Good particle ID
- Good momentum resolution
- High granularity
- High rate capibility
- measure electron, charged hadrons, photon, π^0 , and muons

PHENIX RUN2002 Luminorsity



PHENIX recorded 150nb^{-1} online.

After various cuts,

π^0 analysis: 40nb^{-1}

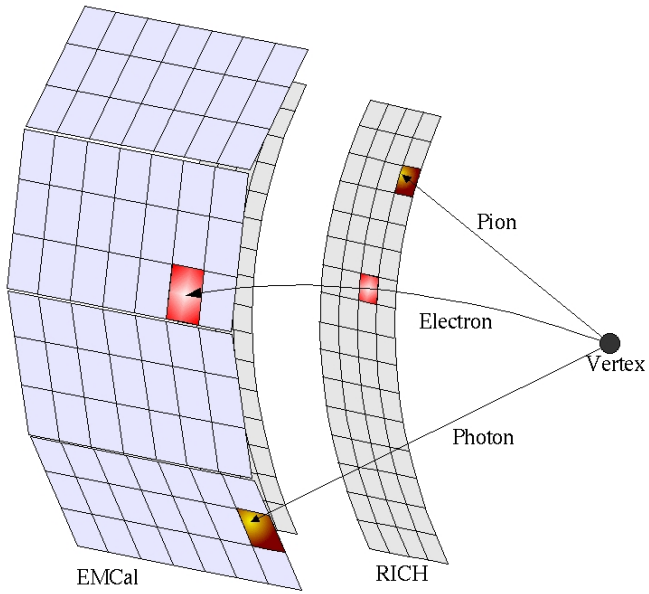
Charged hadron analysis: 40nb^{-1}

$J/\psi \rightarrow e^+e^-$: 48nb^{-1}

$J/\psi \rightarrow \mu^+\mu^-$: 81nb^{-1}

High raw rate requires lvl1 triggers

Central Arm EMCal/RICH LVL1 trigger

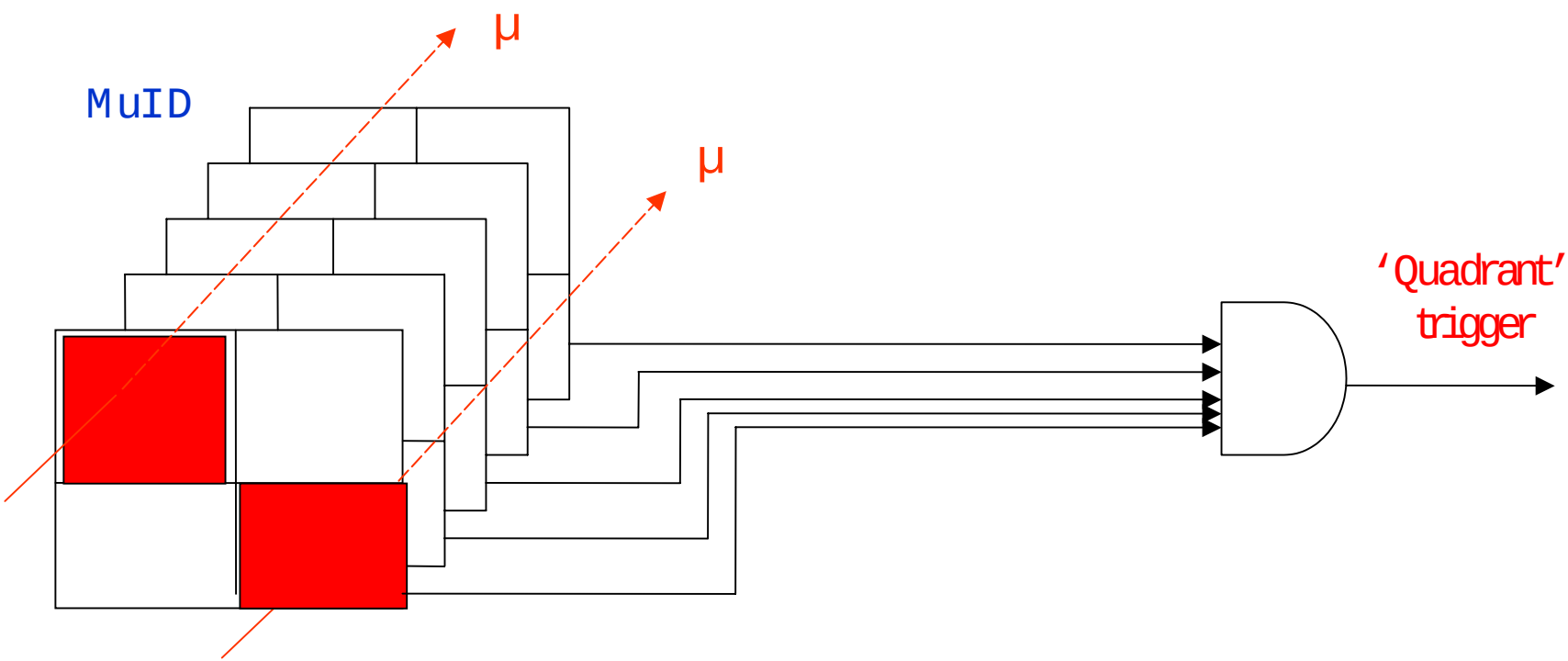


Trigger for photons, electrons, charged hadrons, quarkonium.

Successfully run in 2002 used in $J/\psi \rightarrow e^+e^-$, π^0, charged hadrons, and single electron analysis.

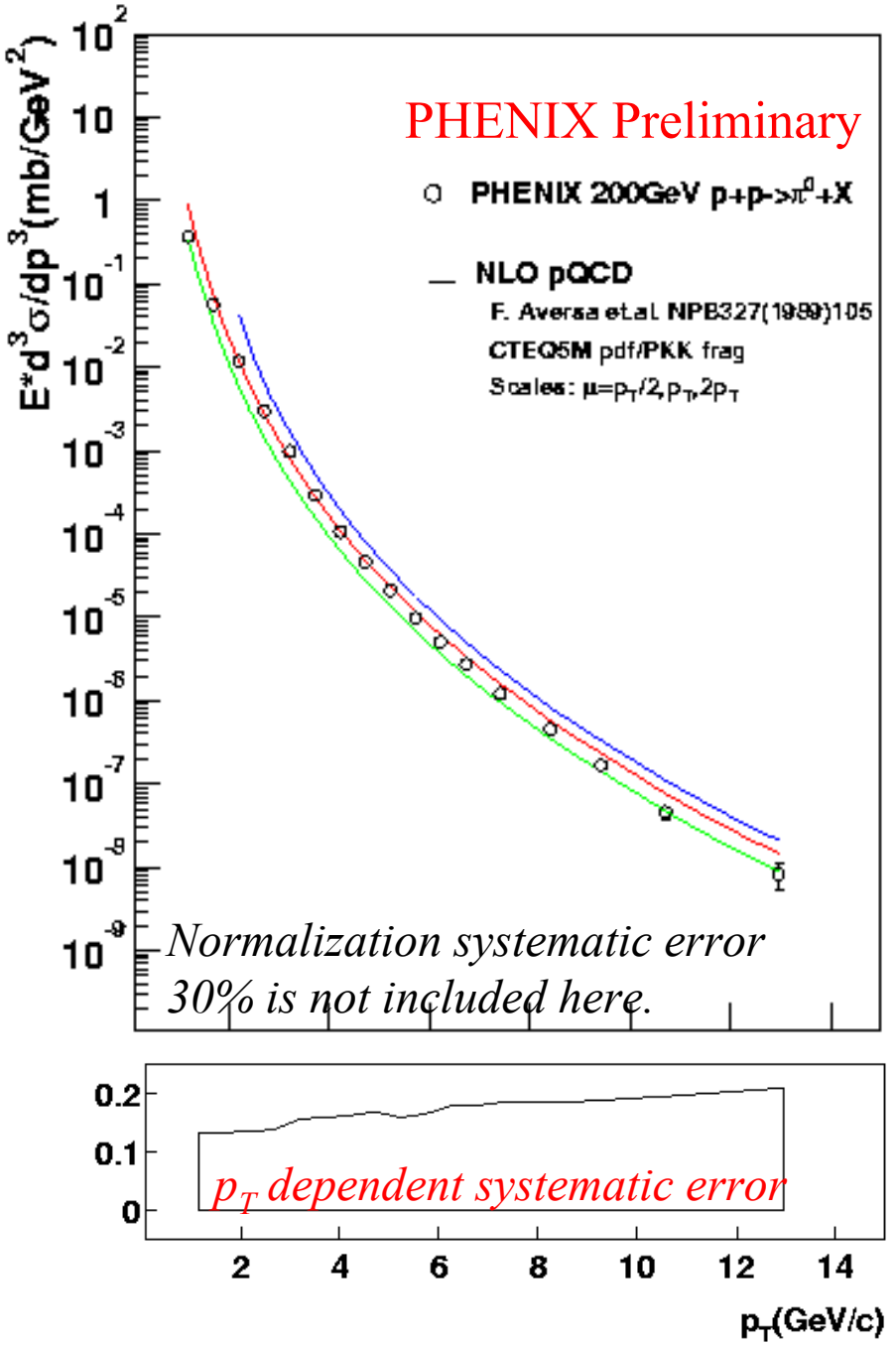
Muon Arm LVL1 trigger

- Coincidence of fired MuID planes of each "quadrant"
- used for J/ψ->$\mu^+\mu^-$ analysis

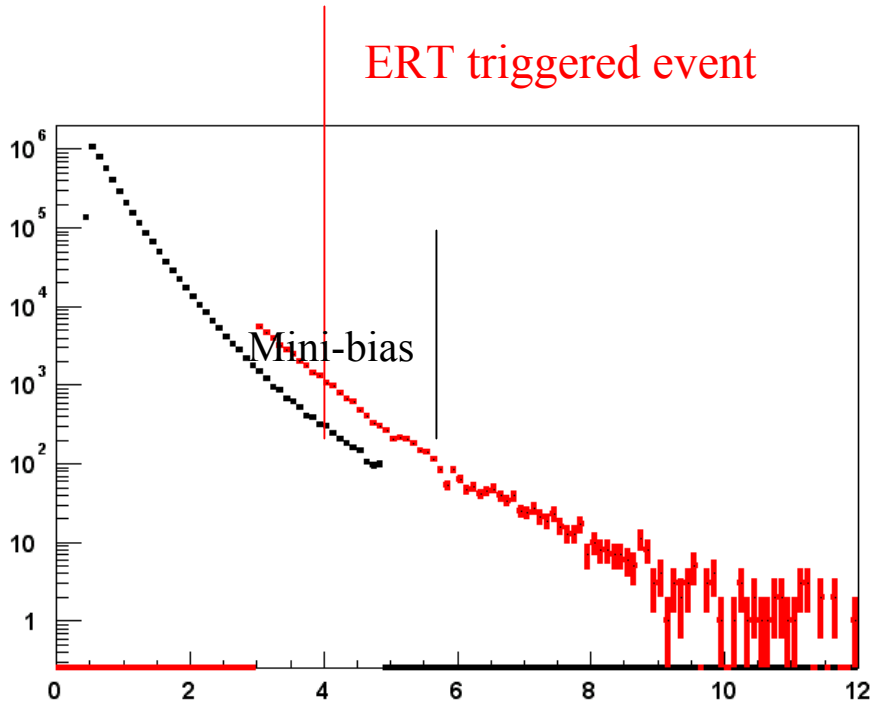


p+p π^0 inclusive cross section

- Minimum-bias trigger covers up to 5GeV, ERT trigger extent to 12GeV
- NLO pQCD calculation with scale dependence is consistent with data down to P_t = 1.5GeV. A solid ground for the interpretation of gluon polarization measurement.
- Compare with Au+Au result shows p_t dependence of suppression.



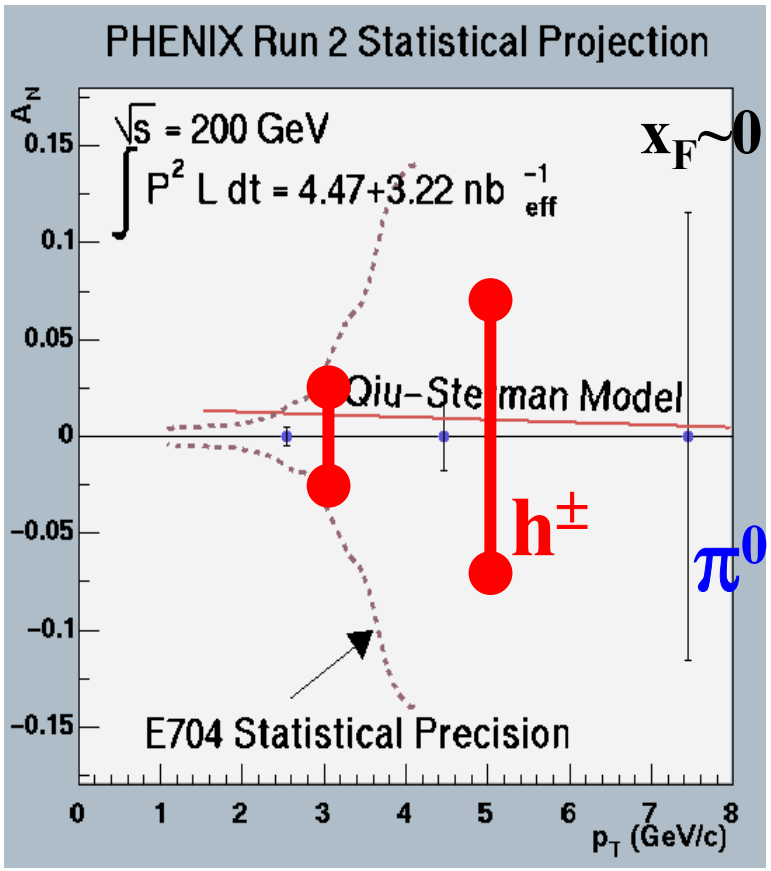
Charge Hadron Analysis in RUN2002



Minimum-bias trigger covers up to 5GeV. EMCal/RICH trigger extent to 10GeV

Analysis to get cross section is on-going..

π^0 and charged hadron Single Transverse Spin in RUN2002



$$A_N = \frac{1}{P}\frac{N_{left} - N_{right}}{N_{left} + N_{right}}$$

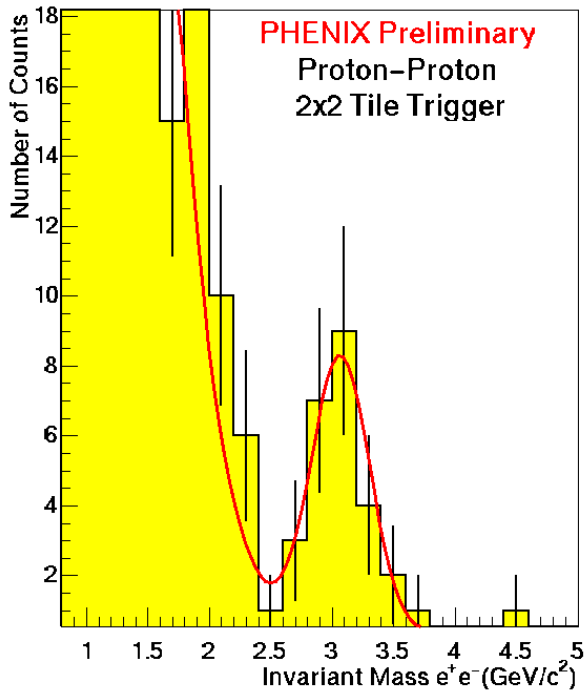
Polarization = 15%,

First measurements in mid-rapidity at $\sqrt{s} = 200GeV$

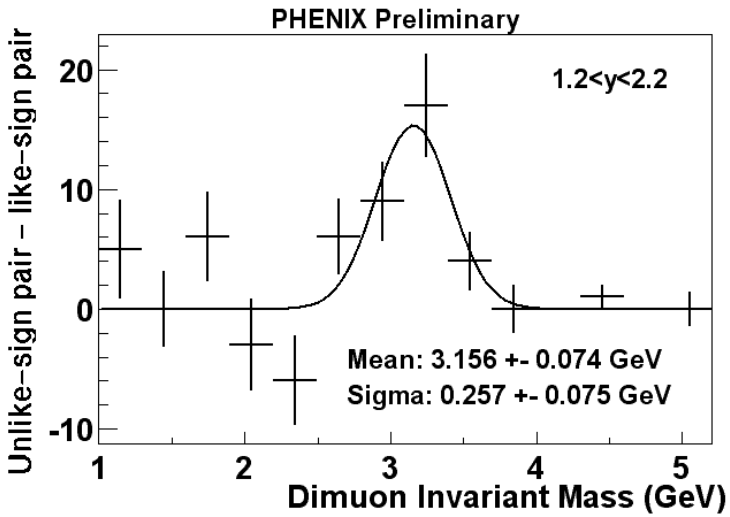
Much smaller statistical error than E704 at $\sqrt{s} = 20GeV$

J/ψ to lepton pairs in RUN2002

(I). signal



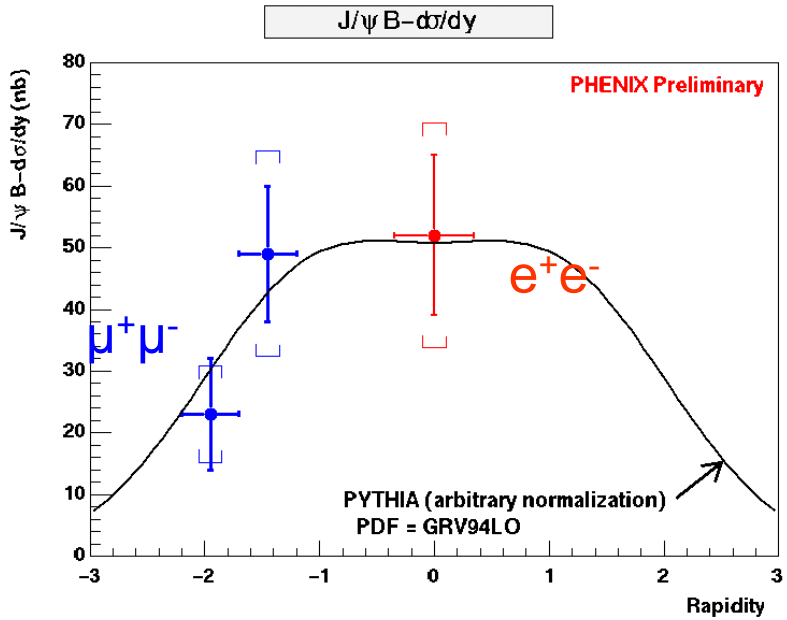
- Mass(ee)

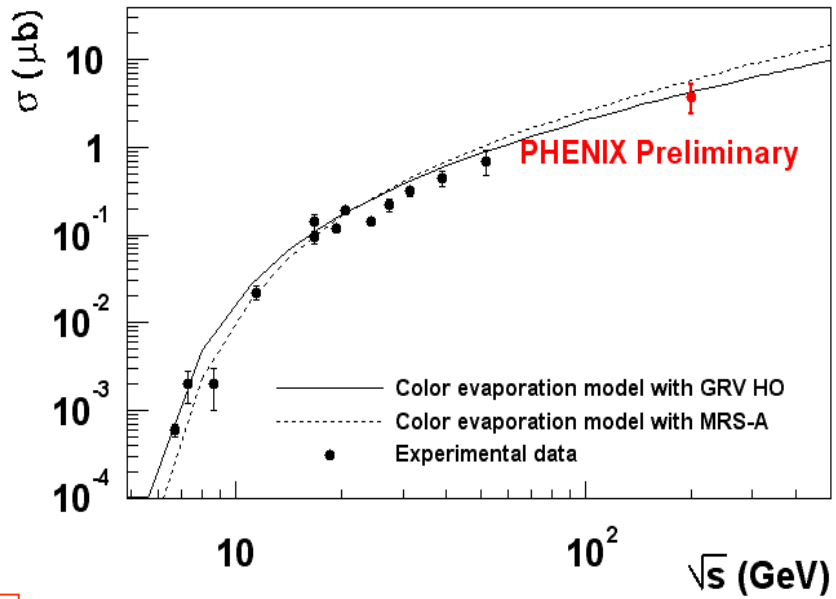


- Mass(μμ)

J/ψ to lepton pairs in RUN2002

(II) J/ψ rapidity distribution and total cross section





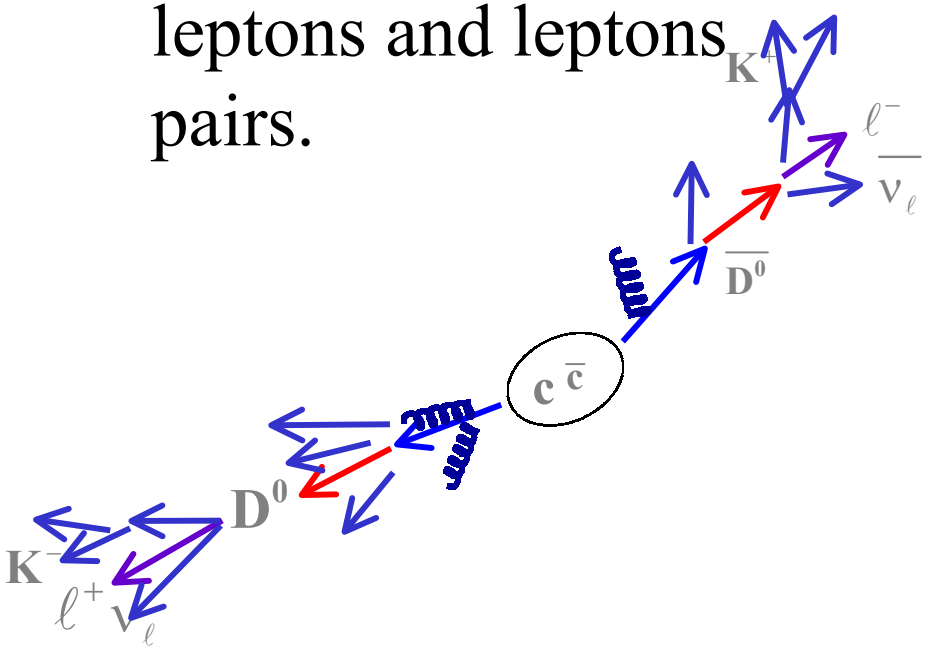
$$Br\,(J/\psi \to l^+l^-)\,\sigma\,(p+p \to J/\psi X)$$
$$= 226 \pm 36\ (stat.) \pm 79\ (sys.)\ nb$$
$$\sigma\,(p+p \to J/\psi X)$$
$$= 3.8 \pm 0.6\ (stat.) \pm 1.3\ (sys.)\ \mu b$$

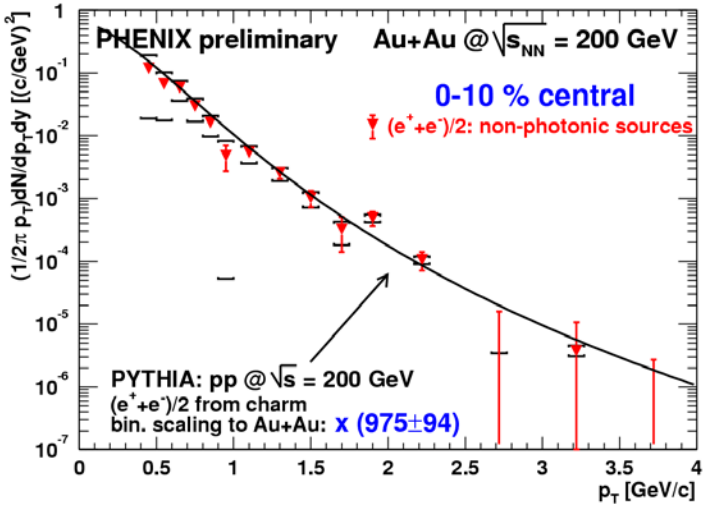
- Our result agrees with the color evaporation model prediction at $\sqrt{s}$=200 GeV
- Result referenced for Au+Au

PHENIX Preliminary

Single lepton from Heavy Flavor Decay

- We can measure open heavy flavor through single leptons and leptons pairs.



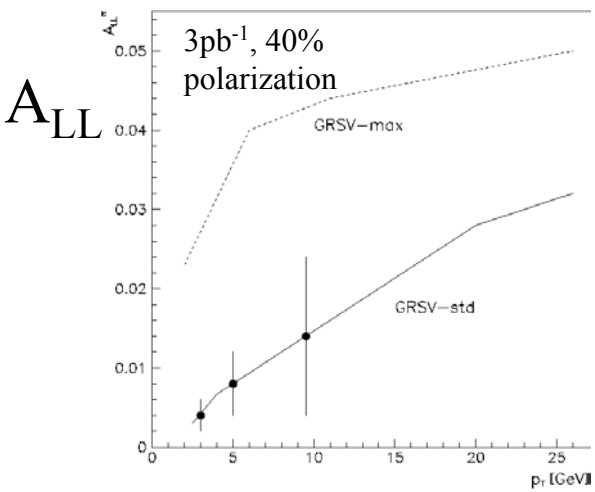


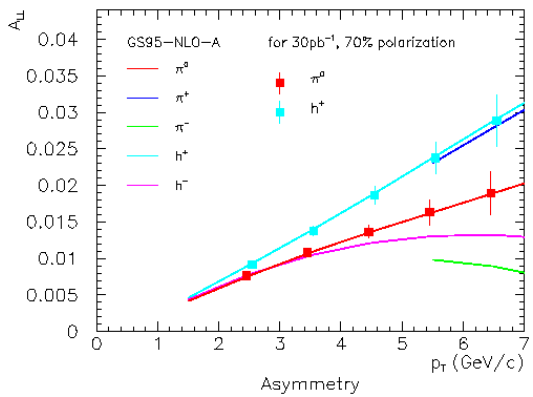
PYTHIA calculation will be replaced by our pp measurement

Gluon Polarization Measurement for Near Future Runs

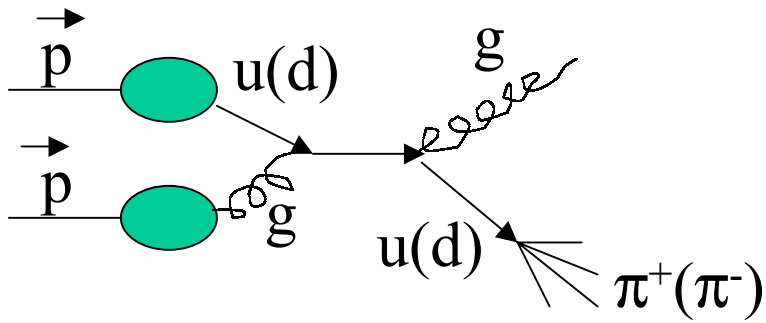
- 2002-2003 run (run-3)
  - *~3pb^{-1} at $\sqrt{s}$=200GeV*
  - *>=40% polarization*
  - *A_{LL} of π^0 and charged hadrons*
- 2003-2004 run (run-4)
  - *~30pb^{-1} at $\sqrt{s}$=200GeV*
  - *>=50% polarization*
  - *A_{LL} of heavy flavor*
    - *J/psi*
    - *single-electron*
    - *start e-μ coincidence*
  - *start A_{LL} of direct photon*

Expectation for A_{LL} of π^0 and charged hadrons





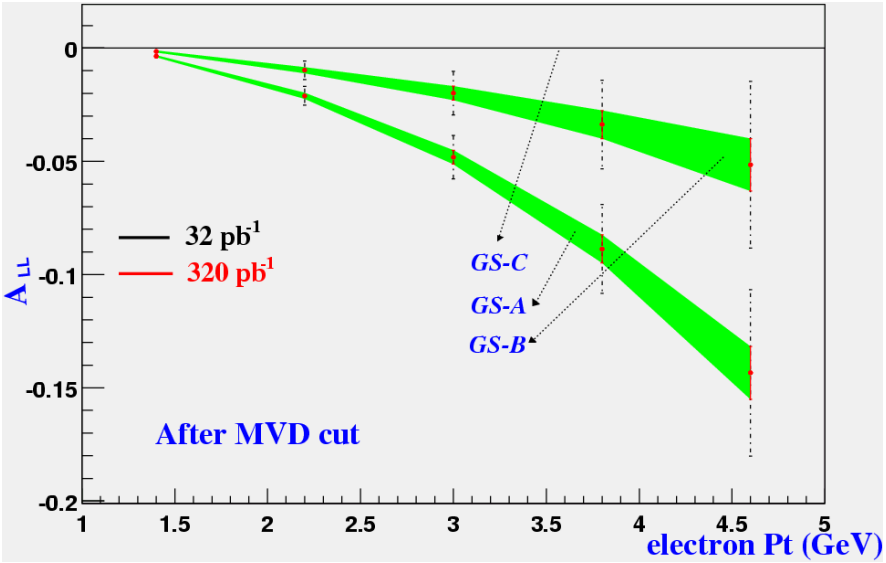
P_t

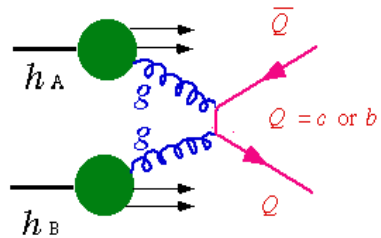


$$A_{LL} \propto \frac{\Delta q(x_1)}{q(x_1)} \frac{\Delta g(x_2)}{g(x_2)} a_{ll}(qg \to qg)$$

- First measurement of ΔG via A_{LL}
- Distinguish different species in RUN4 to have good control over gluon polarization measurement

Expectation of Heavy Flavor A_{LL} measurement

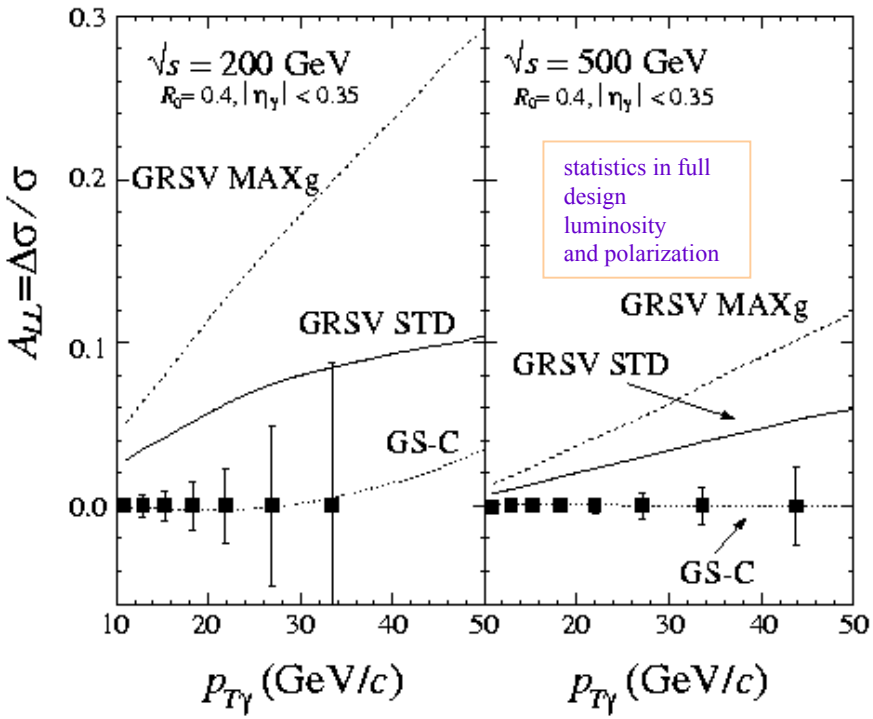


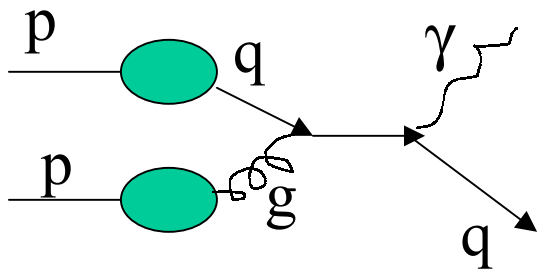


$$A_{LL} \propto \frac{\Delta G(x_A)}{G(x_A)} \otimes \frac{\Delta G(x_B)}{G(x_B)} \otimes \hat{a}_{LL}^{gg \to Q\bar{Q}}$$

Single electron channel

Expectation for A_{LL} on Prompt photon





$$A_{LL} = a_{LL}(qg \to q\gamma)\frac{\Delta g(x_1)}{g(x_1)} A_1^p(x_2)$$

90% from gluon compton scattering, 10% from quark-antiquark annihilation.

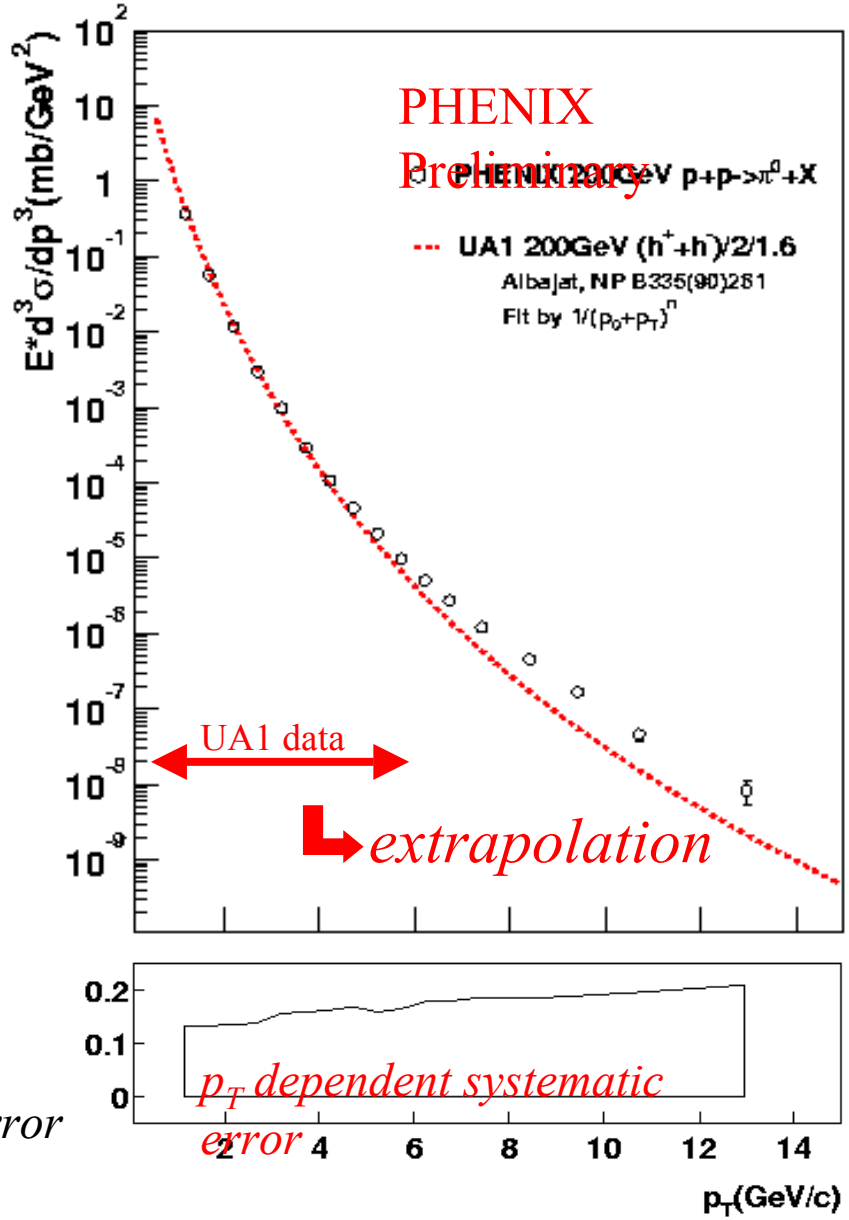
Summary

- PHENIX had a successful RUN in 2002.
  -- *Cross section of π^0 and J/ψ to lepton pairs has been measured and used as reference for our Au+Au results.*
  -- *Comparison with theoretical predictions are done or underway.*
  -- *Cross section for charged hadrons and A_N asymmetry are being analyzed.*
- PHENIX has detailed plan to measure proton spin structure in future runs and expecting high statistics data in pp collisions to form solid ground to interpret results from Au+Au collisions.

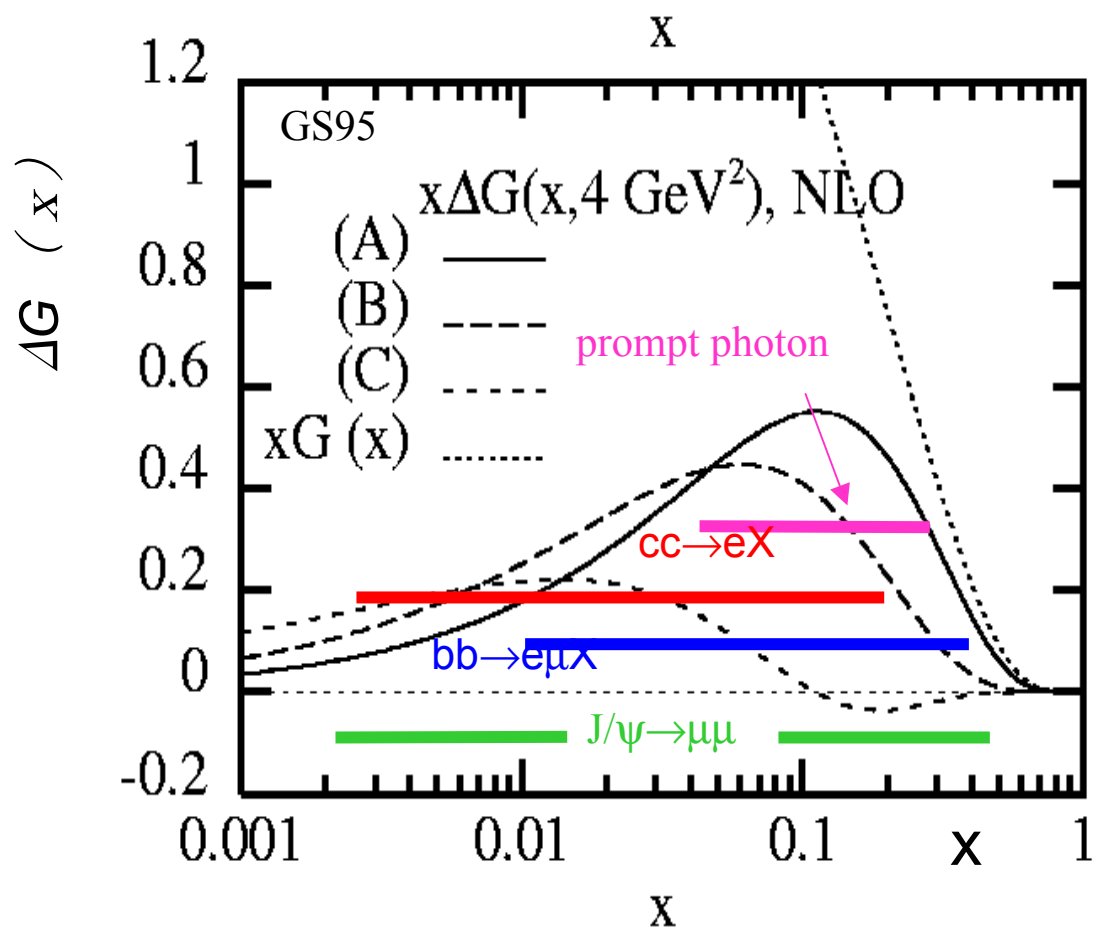
- Back-up slide

Comparison with UA1 Fitting

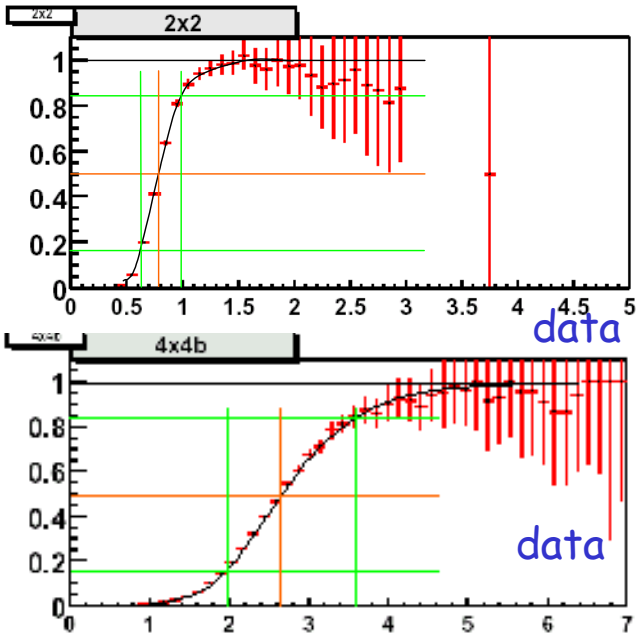
- UA1 has inclusive hadron measurement up to Pt = 6GeV/c. Normalize the cross section using ISR ratio of haron/pion = 1.6 and extrapolated to higher p_T.
- The extrapolation is below our data at high p_T



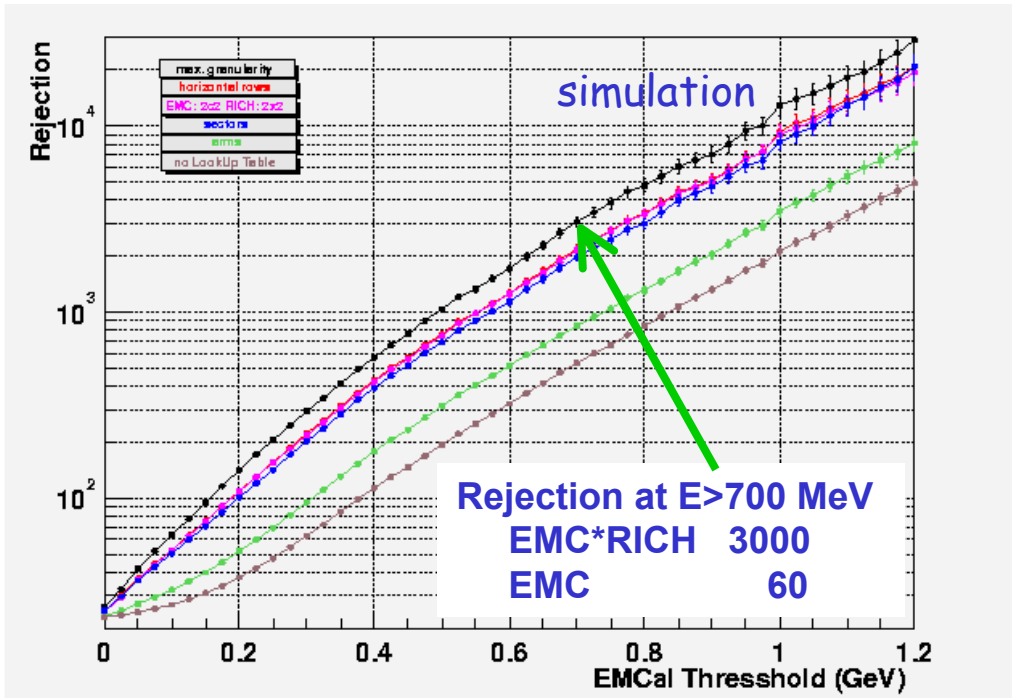
Normalization systematic error 30% is not included here.


x
GS95
xΔG(x,4 GeV²), NLO
(A)
(B)
(C)
xG (x)
prompt photon
cc→eX
bb→eμX
J/ψ→μμ
ΔG (x)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0.001
0.01
0.1
x
1
x

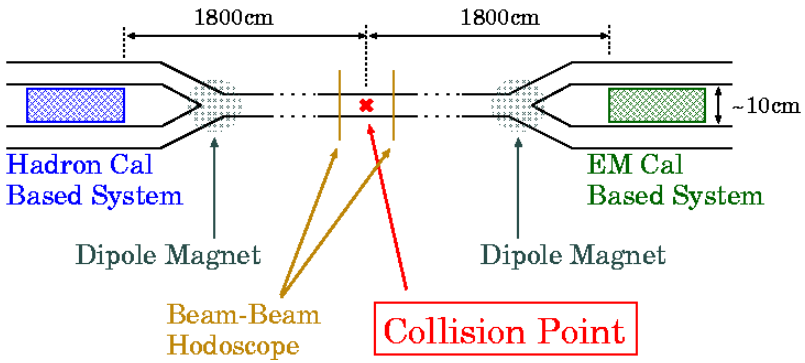
EMCal/RICH trigger Performance



EMCal/Rich Trigger rejection:
Different Granularities



Neutron A_N Measurement at IP12



Observe large asymmetry

Used to monitor and calibrator spin rotater at PHENIX